

Research Summary

Traffic Disruption-free Bridge Inspection Initiative with Robotic Systems

The primary purpose of bridge inspection is to ensure that structures are safe for the travelling public. Since the inception of National Bridge Inspection Standards (NBIS), most updates have been made when new lessons are learned from bridge failures over time. In recent years, however, inspection data has been increasingly used to support a more proactive approach of asset management so that bridge structures are not only safe but can also be maintained with a minimal lifecycle cost. The current practice of bridge inspection on large structures requires the use of snooper trucks and, when parked on bridges, the control of ongoing traffic. It causes an operation safety concern for both passengers and inspectors.

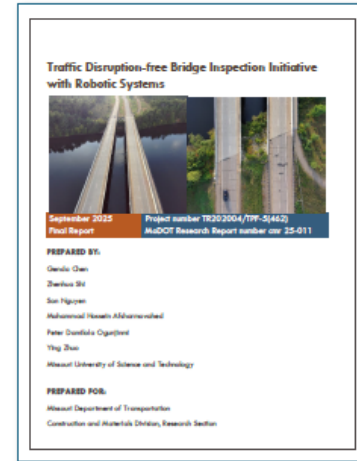
The goals of this pooled-fund initiative were to engage closely with the state Departments of Transportation (DOTs) and leverage the INSPIRE University Transportation Center resources to develop case studies, protocols, and guidelines. These documents can be potentially adopted by state DOTs for bridge inspection with a minimum adverse impact on the traffic. In this study, automated bridge preservation integrated advanced robotics, remote sensing, and nondestructive testing into the practice of visual inspection and associated maintenance.

A framework of automated bridge preservation was developed to integrate advanced robotic,

sensing, and NDT technologies into the visual inspections currently used. While sensing systems always provide quantitative measurements, visual inspection and NDT results are mostly qualitative to the assessment of material deterioration and structural behavior. Their integration is promising in delivering a comprehensive solution in bridge inspection and maintenance.

The alternative robotic technology, referred to as Bridge Inspection Robot Deployment Systems (BIRDS), represents an integration of uncrewed aerial vehicles, structural crawlers, hybrid uncrewed vehicles, remote sensing, nondestructive testing, and computational intelligence. By combining flying, traversing, and crawling capabilities, this invention offers a versatile robotic solution that addresses the limitations of commercial drone technologies in terms of consistent illumination, stationary measurement, precise positioning, and automated data collection for more quantifiable results.

The research team evaluated 59 bridges in diverse types, age groups, and geographical locations. Best practices of the technologies were developed and summarized in inspection protocols and guidelines using commercial drones, structural crawlers, and hybrid uncrewed vehicles. Bridge inspection protocols and guidelines are presented in three parts: pre-



inspection preparation, during-inspection execution, and post-inspection processing.

The type and number of defects observed from the 59 selected bridges in three age groups (15-20, 25-30, and 35-40 years) are limited. Observed deterioration and damage include concrete cracks, concrete spalling, concrete delamination, rebar exposure, and steel corrosion.

Although comparable in time for short-span bridges, the robotic operation is advantageous over its corresponding manual operation in visual inspection. The robotic inspection with multimodal sensors eliminates bridge access challenges and traffic control, improves inspection comprehensiveness for surface and subsurface defects, enhances inspection objectivity and quantification, and extends the usefulness of inspection reports in developing maintenance strategies. For long-span bridges, the robotic solution is also significantly more efficient than the visual inspection.



Figure 1: Microscope crawler for detailed visual inspection.

Project Information

PROJECT NAME: TR202004/TPF-5(395)—Traffic Disruption-free Bridge Inspection Initiative with Robotic Systems

PROJECT START/END DATE: August 2019-July 2025

PROJECT COST: \$725,000

LEAD CONTRACTOR: Missouri University of Science and Technology

PRINCIPAL INVESTIGATOR: Genda Chen

REPORT NAME: Traffic Disruption-free Bridge Inspection Initiative with Robotic Systems

REPORT NUMBER: cmr 25-011

REPORT DATE: September 2025

Project Manager



CONTACT INFORMATION:

Jennifer Harper
Research Director
Missouri Dept. of Transportation
1617 Missouri Blvd.
Jefferson City, MO 65109
(573) 526-3636
Jennifer.Harper@modot.mo.gov